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FINAL STANDARD OPERATING PROCEDURE

Radon Screening of Buildings at the
Umatilla Depot Activity
Hermiston, Oregon

Prepared for:
U.S. Army Toxic and Hazardous Materials Agency
Aberdeen Proving Ground, Maryland
Contract No. DAAA15-88-D-0008, Delivery Order No. 3

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DAMES & MOORE
7101 Wisconsin Avenue, Suite 700, Bethesda, Maryland 20814

July 1990

DAMES & MOORE A PROFESSIONAL LIMITED PARTNERSHIP
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July 24, 1990

U.S. Army Toxic and Hazardous
Materials Agency
Building E4435
Aberdeen Proving Ground, MD 21010

Attn: CETHA-IR-A/Ms. Joan Jackson

Re: Final Standard Operating Procedure (SOP)
Radon Screening of Buildings at the
Umatilla Depot Activity (UMDA)
Hermiston, Oregon
Contract No. DAAA15-88-D-0008
Delivery Order No. 3

Dear Ms. Jackson:

This letter transmits five (5) copies of the above-referenced radon SOP for UMDA. It incorporates the comments of USATHAMA and AEHA, which were transmitted on July 10, 1990.

In accordance with USATHAMA's comments, we understand that, due to funding limitations, we are not authorized to place more than 400 detectors (including blanks at a rate of 10 percent) in this survey. With regard to this issue, AEHA comment 1.b indicated that the use of duplicates, at a rate of 10 percent, should be considered. Considering the budget constraint on this project, it will not be possible to deploy duplicate detectors, nor is it necessary for reasons stated in Section 2.2.3 of the SOP.

Please contact me if you have any questions or need additional copies of the SOP. Planning for the survey is proceeding; work onsite will begin in early August in conjunction with the asbestos survey.

Sincerely,

DAMES & MOORE

Stephen Lemont
Project Manager

SL/mb

Enclosures

CONTENTS

LIST OF ACRONYMS AND ABBREVIATIONS

BRAC	Base Realignment and Closure
cm	centimeter
DOD	U.S. Department of Defense
ID	Identification
mm	millimeter
PA	Preliminary Assessment
pCi/l	picocuries per liter
QA	Quality Assurance
QC	Quality Control
RMP	Radon Measurement Proficiency
RSPM	Radon Survey Project Manager
SOP	Standard Operating Procedure
sq. ft.	square feet
UMDA	Umatilla Depot Activity
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency
USEPA	U.S. Environmental Protection Agency
HVAC	Heating, ventilation, and air conditioning

1.0 INTRODUCTION

This document is the Standard Operating Procedure (SOP) for a radon screening of existing buildings at the Umatilla Depot Activity (UMDA), Hermiston, Oregon. The U.S. Army Toxic and Hazardous Materials Agency. (USATHAMA) has contracted with Dames & Moore--under Contract No. DAAA15-88-D-0008, Delivery Order No. 3--to conduct this survey in support of the U.S. Department of Defense (DOD) Base Realignment and Closure (BRAC) Program at UMDA. The Army wants to be aware of any potential or existing radon problems in buildings at UMDA that would be left in place at the time of base closure. It is noted that currently unoccupied or minimally occupied buildings may be heavily occupied under possible future use scenarios (such as use of the facility as an industrial park).

The objective of the radon survey will be accomplished by conducting the following tasks. Note that a total of no more than 400 radon samples (including blank samples at a rate of 10 percent) is authorized.

- Conduct of an initial building survey to collect information on and evaluate building characteristics for the determination of optimal locations for radon collector placement in each of the approximately 238 existing buildings at the installation. (Note that the 1,001 storage igloos are not included in this survey.)
- Alpha track radon detector placement and retrieval and conduct of laboratory analyses for radon.
- Conduct of a supplementary building survey--limited to buildings in which exceedances of the U.S. Environmental Protection Agency. (USEPA) 4-picocurie/liter (pCi/l) guideline for radon were noted--which includes additional visual assessment and measurements, as appropriate, to provide information for the determination of additional surveys or remedial measures. Note that the supplementary survey will not be conducted unless there is sufficient budget available as a result of the prior collection of fewer than 400 radon samples (including blanks).

- Preparation of a Radon Survey Report detailing the methodology, analytical results, all other relevant observations for each building and preliminary recommendations for remedial activity.

The radon survey to be conducted, as described herein, is considered to be somewhat limited in scope--and, therefore, a screening tool rather than a comprehensive survey--for the following reasons:

- Fewer than one detector per 2,000 square feet (sq. ft.) of ground contact space per building--as recommended in the USEPA Radon Measurement Protocol adopted by the General Services Administration[1]--will be placed in most cases.

- Measurements are tentatively planned during worst case conditions, in the extreme cooling season of summer 1990. Dames & Moore will, to the extent possible, coordinate with UMDA so that UMDA can endeavor to produce, as closely as possible, a "closed house" situation for the 90-day test.

However, because we believe that the nature of this survey is intended by the Army to be one of a preliminary assessment process, and because the underlying rock formation at UMDA is basalt indicating that the potential for elevated radon levels may be limited, the approach described in this SOP could be adequate as a screening tool.

A previous radon survey at UMDA deployed 90-day detectors on May 31, 1989, in 17 buildings. We understand, however, that this survey was subsequently considered invalid and will soon be repeated. Types of buildings included in this survey were family housing, occupied offices, and a few unoccupied buildings. It is not intended to use the results of this survey to reach conclusions in the survey described herein. However, these data, when available, maybe compared with the new data to supplement and/or assist in the interpretation of results.

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[1] General Services Administration, Memorandum for Regional Administrators. Subject: Implementation of GSA Radon Program, Public Buildings Service, Washington, D.C. 20405.

The remainder of this SOP presents the technical approach to the radon survey, interpretation of results, and report preparation. Information on personnel organization and qualifications and a tentative survey schedule are also presented.

2.0 TECHNICAL APPROACH

2.1 INITIAL BUILDING SURVEY

An initial building survey--to assess the size, usage, and types of buildings--will be conducted prior to the placement of the radon detectors. The primary objective of this initial survey will be to determine the number of detectors per building and approximate locations for placement. The data collection and review. effort will focus on information needed for this determination, in accordance with the detector placement rationale in Section 2.2.2. All existing buildings and their locations will have been previously identified and mapped as a part of the Enhanced Preliminary Assessment (PA) of UMDA conducted by Dames & Moore. Other information collected during the PA will be reviewed, including current and previous usage, building status (i.e., active or inactive), date of construction, construction materials, and available building drawings. Additional information will be obtained via walk throughs of selected buildings and discussions with present and past UMDa employees, as necessary.

Placement of all radon detectors will be conducted immediately following the initial building survey so that all detectors can be retrieved at the same time following the sampling period. However, if the total number of detectors (including blanks) recommended for placement is greater than 400, Dames & Moore will attempt to prioritize the locations to be sampled because the scope of work of the project budget is limited to 400 total samples.

2.2 INITIAL RADON SAMPLING

2.2.1 Type of Radon Detector

An alpha track detector is a commonly used, USEPA recommended device for the long-term measurement of indoor radon levels; 90-day alpha track detectors will be used in this survey. The advantage of alpha track detectors over other radon

sampling devices is that relatively long-term concentration values can be obtained, as opposed to short-term (48-hour) or grab radon sampling levels.[2]

The detector to be utilized is a small cylindrical vial about 2.5 centimeters (cm) tall and 2.5 cm in diameter containing a 14- x 21-millimeter (mm) chip of alpha particle sensitive CR-39 plastic. The detector housing is made of conductive, high-impact polystyrene. The cap contains a polyethylene sheet which serves as a barrier or filter to prevent the entry of dust particles and radon progeny. A round tag with a permanent identification (ID) number is applied to the detector cap. In addition to the ID number with five digits, three letters are used to allow unique identification of the detectors. Both the numbers and the letters are also engraved on every chip, providing unique identification of each detector and chip. The detector cannot be opened except by breaking the cap. Thus, the possibility of tampering and erroneous removal of the cap, leading to uncalibrated exposure of the detector chip, is minimized.

A label is supplied with every detector to record the starting and ending dates of the exposure. Additionally, every detector has either an information strip or card, listing the shipping date and recipient, and allowing the name, address, exposure times, and location to be recorded.

Each detector is also supplied with a mounting device allowing it to be attached to a suitable wall, ceiling, or joist at the exposure site.

For protection before and after deployment, detectors are sealed in metallized plastic bags, which have been shown to reduce radon entry by approximately 80 percent.

2.2.2 Detector Placement and Collection

Alpha track radon detectors will be placed for a period of 90$\pm$2 days. After 90$\pm$2 days, the detectors will be collected and shipped as outlined in Section 2.2.5. In general, placement of the detectors will follow the protocol/rationale presented below.

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[2] State of Maryland Department of the Environment. Alpha Track Detection, 1 page information reference.

- At least one detector will be placed in each building, if appropriate. The need for and placement of additional detectors will be based on the professional judgement of the Radon Survey Project Manager (RSPM) which, in turn, will be based on such factors as building size and structure; existence of penetrations cracks, openings, etc.; and building ventilation. Detector locations will be justified in the Radon Survey Report. No more than one detector per 2,000 sq. ft. of ground contact space per building will be placed.

- Detectors will be placed in a building level which is in ground contact (below or at grade).

- Detectors will be placed in areas permanently occupied, areas that are occupiable, and/or areas routinely visited, which are on floors directly in ground. contact or over/adjacent to a crawl space or void in ground contact.

- To reduce tampering with the detectors, signs will be posted at detector locations stating the following: "90 DAY RADON TEST IN PROGRESS. DO NOT TOUCH" (See Attachment 1).

- Detectors will be placed in enclosed areas/rooms expected to have a relatively low ventilation rate (e.g., interior rooms with no windows and tight doors).

- Detectors will not be placed directly in areas/rooms where ventilation systems mix outdoor and indoor air or where there is high air circulation or exhaust fans.

- Detectors may be closely adjacent to, but not directly in, inaccessible areas such as closets, sump pumps, crawl spaces, or nooks within building foundations.

- Detectors will be placed in areas (where found) with cracks in walls or floors, where there are penetrations of floors or walls (by electrical conduits, cables, pipes, etc.), areas with outside corners, and where

construction or expansion joints are present. Detectors hung from ceilings will be placed at least 8 inches below the ceiling.

A graphic representation of the detector placement decision process is presented in Attachment 2. Optimal detector locations are building areas directly in ground contact (i.e., the walls and floor of the lowest level of the building). The closest alternative to this is an area that is over or adjacent to a crawl space, penetration, or void in ground contact. Once either of these two criteria are met, the rationale for detector placement is to find an area that is enclosed, with relatively little or no ventilation; this is to ensure that maximum potential levels are obtained because increased ventilation will tend to lower and dissipate radon levels in buildings. If the area is normally occupied, detector placement should include areas permanently occupied or routinely visited by the occupants.

Personnel conducting detector placement and retrieval will generally be working alone. However, it is assumed that installation personnel will be available for assistance in obtaining access to buildings and building areas, providing information on building areas, etc.

2.2.3 Blanks and Duplicates

Blanks and duplicates are sometimes used as quality control (QC) samples in radon surveys. Blanks--which are unopened collectors that are shipped to the field, kept with the parking material, and returned with the samples--are essential for the purposes of (1) establishing background levels, (2) establishing a point of reference for accurate interpretation of the sampling results, and (3) ensuring QC. Ten percent blanks will be included in the survey. Blanks are repackaged and shipped with the lot of detectors with which they were originally shipped.

Duplicates may add statistical significance to findings, but are not essential. A duplicate consists of a second detector placed adjacent to the primary detector; both detectors are handled and analyzed in an identical manner. However, duplicates will not be used in this program because the laboratory to be used will have met the requirements of the USEPA-sponsored Radon Measurement Proficiency (RMP) Program.

2.2.4 Sampling Documentation

A standardized radon sampling form (Attachment 3) will be utilized for the purpose of documenting sample information. Information clearly describing the location of each detector will be included on the form. There will be no building drawings prepared for this survey; thus, all locations must be clearly described. As shown in Attachment 3, the following information will be recorded for each radon sample:

- Detector serial number
- Location of sample (i.e., precise location in the building)
- Dates of detector placement and retrieval
- Comments (e.g., any unusual conditions, such as building unoccupied, windows, HVAC on or off, obvious openings to soil, etc., and information relevant to the justification for the detector location)
- Results in pCi/l (when obtained from the laboratory).

In addition, each form will include the facility name and location (i.e., Umatilla Depot Activity, Hermiston, Oregon) and building number, and name, and will identify the person(s) placing and retrieving the detectors.

2.2.5 Sample Handling and Shipment

Alpha track radon detectors will be handled in accordance with manufacturer's specifications and laboratory instructions. Generally, use of these detectors involves removal from the sealed, metallized plastic bag, removal of any paper or other coverings (as appropriate), and attachment into place at the exposure site using thumb tacks or staples. Upon retrieval, the detector is returned to the metallized plastic bag. Unless instructions indicate otherwise, the detector cap is never removed as this leads to uncalibrated exposure of the detector chip. Upon return to the laboratory, the detectors are shipped in the metallized plastic bags that they originally came in.

Retrieved detectors will be shipped to the laboratory daily or every other day via United Parcel Service or similar carrier. Shipment by overnight courier is

unnecessary. Chain-of-custody forms (see Attachment 4) will be included with each shipment to ensure the integrity of the samples.

2.2.6 Analysis of Samples

Radon detector analyses will be performed by a laboratory successfully participating in the RMP Program. Barringer Laboratories: Inc., Golden, Colorado, has been tentatively selected for this project. Information on Barringer's quality assurance (QA) program and analytical methodology for alpha track detectors is provided in Attachment 5.

2.3 SUPPLEMENTARY BUILDING SURVEY

According to USEPA guidelines (see Section 3.1), radon sample measurements in excess of 4 pCi/l indicate cause for concern. Thus, after the initial radon results are obtained from the lab, additional survey activities will be recommended to be conducted in buildings in which exceedances of the 4-pCi/l level are detected. These activities may include additional visual assessment and measurement, focusing on the collection of information for the determination of remedial measures. It is anticipated that only a small percentage of the total number of buildings will require supplementary survey, based on previous radon sampling experience throughout the United States and on the low probability of radon problems in the UMDA area. If budget allows, this supplemental survey will be done under this contract; if not, USATHAMA will contract these services via separate contract.

Specifically, the supplementary building survey can include one or more of the following activities, as appropriate to each building:

- Building inspections to note features relevant to remedial action (e.g., potential opening in the building envelope to the soil, structure and condition, ventilation).
- Short-term resampling, involving placement of a determined number of 48 hour activated charcoal adsorption canisters at representative locations under near worst-case conditions (e.g., keeping windows and doors closed). (See Attachment 6 for analytical and QA/QC procedures.)

- Determination of ventilation and air movement factors using an air current detector (smoke tube).

These activities will aid in determining the significance of apparently high initial radon levels and provide a cost-effective means to suggest remediation alternatives in the relatively few locations which may present problems.

Prior to implementation of any supplementary building survey, USATHAMA will be provided with a brief written plan of action identifying the buildings to be evaluated and the tentative scope of additional work to be performed in each.

3.0 DATA INTERPRETATION AND REPORT

3.1 DATA INTERPRETATION

Laboratory results for alpha track detectors will be transferred to the radon assessment sampling forms and also compiled in tabular form for evaluation. As per the USEPA Radon Sampling Protocol, the following guidelines are given for interpretation of the analytical results.[3]

- Sample measurements at or below the USEPA radon guideline of 4 pCi/l are considered average or slightly above average for interior environments. Although exposures in this range do present some risk of lung cancer, reductions of levels this low maybe difficult, and sometimes impossible, to achieve.

- Samples measurements between 4 pCi/l and 20 pCi/l are considered above average for interior environments. Action to reduce levels at or below 4 pCi/l should be undertaken within a few years (sooner for higher levels). Also, resampling of the area should be done during another season of the year to confirm levels.

- Sample measurements between 20 pCi/l and 200 pCi/l are considered greatly above average for interior environments. Actions to reduce levels as far below 20 pCi/l as possible should be undertaken within several months.

- For sample measurements: at or above 200 pCi/l, action to reduce levels as far below 200 pCi/l as possible should be undertaken within several weeks. Temporary relocation of inhabitants may be appropriate until levels are reduced.

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[3] U.S. Environmental Protection Agency, Office of Air and Radiation, and U.S. Department of Health and Human Services, Centers for Disease Control, August 1986. A citizen's Guide to Radon: What It Is and What to do About It, OPA-86-004.

Buildings potentially requiring remedial action will have been further evaluated in the supplementary building survey. The resulting information on building characteristics, air movement patterns, and radon levels will be used to identify preliminary remedial action alternatives.

3.2 SURVEY REPORT

A Radon Survey Report will be prepared--in draft and final versions-detailing the analytical results for each building and recommendations for additional surveys or remedial action. No building drawings or other illustrations will be included; it is assumed that descriptions of sample locations will suffice. Also included in the report will be survey and sampling methodologies, original analytical results and sampling forms; interpretation of the sampling data, visual observations, and field measurements; recommendations for additional sampling or other investigations; and other relevant information and documentation.

The tentative radon survey report format is as follows:

- Executive Summary
- Introduction
    - Background
    - Objectives
    - Scope of Work Overview
- Survey Methodologies
- Sampling Documentation and Test Results
- Interpretation of Results and Discussion
- Conclusions
- Recommendations
- Appendices.

4.0 PERSONNEL

The radon survey will be directed by a Radon Survey Project Manager (RSPM) located in the Dames & Moore Bethesda, Maryland, office. This person will also direct, as well as participate in, the building surveys and in detector placement and collection. The RSPM--an experienced industrial hygienist/indoor air quality specialist--will be responsible to the overall UMDA Project Manager, Dr. Stephen Lemont, and will interface with the USATHAMA Project Officer and UMDA personnel in coordinating fieldwork efforts and discussing technical issues. Detector placement and retrieval will be accomplished by trained field technicians.

5.0 SCHEDULE

With USATHAMA approval, initiation of the initial building survey and detector placement is planned for early August 1990. A tentative schedule is shown in Attachment 7. Following alpha track detector placement, there is a required 90-day waiting period. before the detectors can be retrieved. The supplementary building survey, including 48-hour resampling (where needed), will begin after the alpha track results have been obtained and USATHAMA concurrence with the proposed plan of action is received. Assuming 3-week periods for USATHAMA review and comment of the Draft Radon Survey Report and for final report preparation after receiving comments, the project should be completed by May 1991.

ATTACHMENT 1

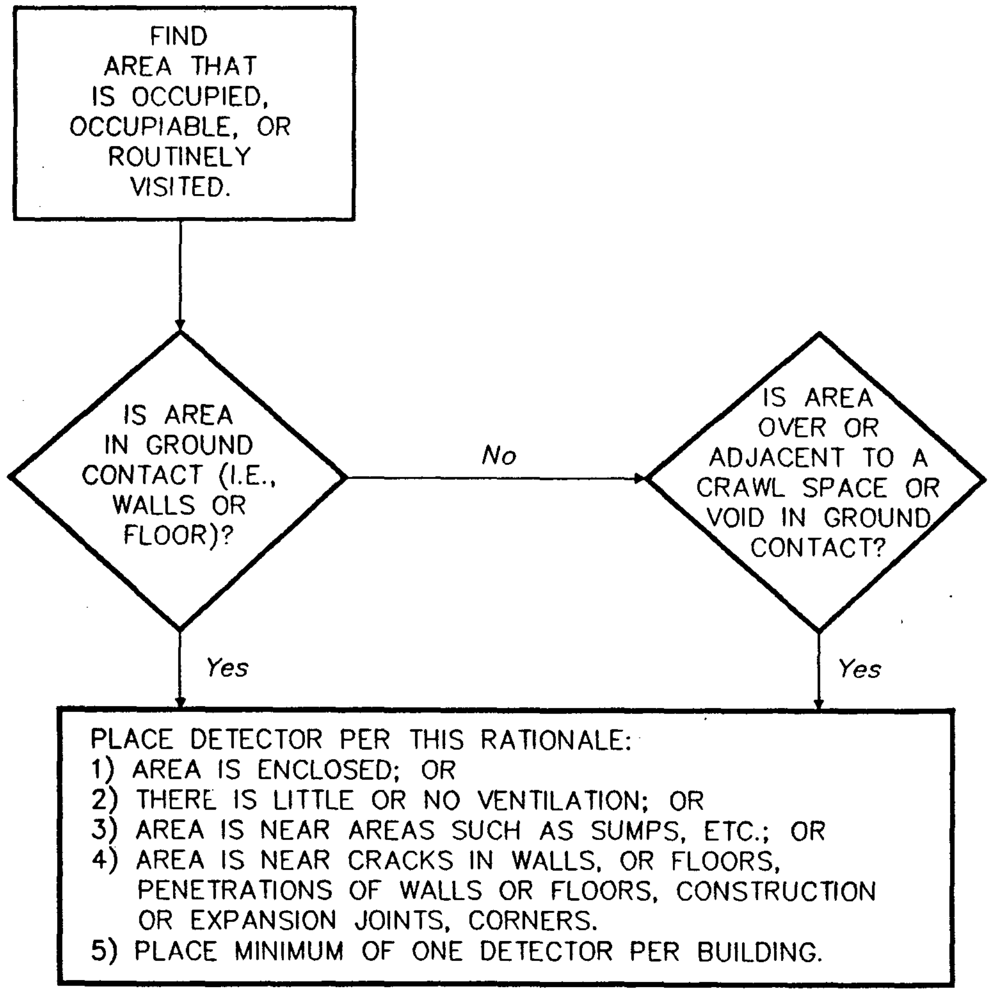
Example – Sign Posted During Radon Survey

90 DAY RADON TEST IN PROGRESS

DO NOT TOUCH

90 DAY RADON TEST IN PROGRESS

DO NOT TOUCH



ATTACHMENT 2
DECISION PROCESS FOR PLACEMENT OF RADON DETECTORS

DAMES & MOORE

Dames & Moore

ATTACHMENT 3

RADON SURVEY SAMPLING FORM

Facility Name ______________________ Person Placing Detectors ______________________

Facility Location ______________________ Person Retrieving Detectors ______________________

Building Number and Name ____

Detector Serial #	Location	Detector Placement Date	Detector Retrieval Date	Results in picoCuries per Liter of air (pCi/l)	Comments

PROJ. NO.	PROJECT NAME
SAMPLER'S: (Signature)	

Sta. No.	Date	Time	Comp.	Grab	Station Location	No. of Containers								REMARKS

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks:	

Distribution: Original Accompanies Shipment; Copy to Coordinator Field Files

ATTACHMENT 4
SAMPLE — CHAIN OF CUSTODY FORM

Dames & Moore

ATTACHMENT 5

Barringer Laboratories Inc.
Radon Measurement Program and
QA/QC Procedures for
Alpha Track Detector

QUALITY ASSURANCE PLAN

RADON MEASUREMENT PROGRAM

BARRINGER LABORATORIES INC.
15000 WEST 6TH AVENUE, SUITE 300
GOLDEN, COLORADO 80401

ALPHA TRACK DETECTOR

MAY 1989

TABLE OF CONTENTS

BARRINGER ALPHA TRACK DETECTORS

Barringer Laboratories Inc. is a primary supplier of alpha track detectors (ATDs) and ATD analytical services for the GSA radon program. Barringer is also a supplier of alpha track detectors to private, corporate, and state and federal government clients and has a projected capacity to produce and analyze up to 500 detectors per day.

The alpha track detector system is based upon a small rectangle of CR-39 polycarbonate plastic, which is sensitive to molecular damage by alpha particles resulting from the radioactive decay of radon gas and it daughter products. After exposure, the areas of damage are enlarged by etching the plastic chips with strong alkali, to produce distinctive pits in the surface of the plastic. Each pit reflects the impact of a single alpha particle. The number of pits is then counted under a microscope and a measure of the exposure level can be determined. In order to exclude other sources of alpha particles such as radionuclides that are attached to dust particles and preexisting solid radon daughter products, the chips are supplied in sealed containers with a tightly fitted lid. The lid is lined with a soft plastic seal which permits the diffusion of radon into the container, but excludes solid particles.

The Barringer alpha track detector was originally developed and tested by the Canadian Government and has been used extensively in Canadian radon measurement programs. The Barringer detector is a small cylindrical vial about 2.5cm tall and 2.5cm in diameter containing a 14m x 21mm chip of alpha particle sensitive CR-39 plastic (Figure 2.1). A round tag with the permanent ID number is applied to the cap. In addition to the ID number with five digits, three letters are used to allow unique identification of the detectors. Both the numbers and the letters are also engraved on every chip, providing unique identification of each detector and chip. The detector cannot be opened except by breaking the cap. Thus, tampering and erroneous removal of the cap, leading to uncalibrated exposure of the detector chip, is minimized.

A label is supplied with every detector to record the starting and ending date of the exposure. Additionally, every detector has either an information strip or card, listing the shipping date, recipient, and allowing the name, address, exposure times and location to be recorded.

Each detector is also supplied with a mounting device allowing it to be attached to a suitable wall, ceiling or joist at the exposure site.

The dectector housing is made of conductive, high-impact polystyrene. The cap contains a polyethylene sheet serving as a barrier or filter to prevent the entry of dust particles and radon progeny.

The dectector chips are laser-cut from sheets of high-quality CR-39 poly-carbonate plastic. The liquid base material is manufactured by Pittsburgh Plate Glass in Akron, Ohio, and the sheets are cast by a number of manufacturers. The detector material is ordered in batches of ten to fifty sheets, and each sheet yields about 500 detector chips. Barringer chips are 14 x 21mm in size, and are about twice as large as the chips used by competitors. The larger size facilitates processing, marking and handling, and results in improved quality control. The larger area also offers better precision and accuracy, in that many more fields of view are available for counting.

Barringer has not only used a consecutive numbering system for its detectors but has also created unique project numbering systems for clients to aid them in managing the deployment, retrieval and reporting of the data.

For protection before deployment, detectors are sealed in metallized plastic bags, which have been shown to reduce radon entry by approximately 80%.

Quality Assurance Program

Barringer maintains a rigorous quality assurance program. As part of this program, it has participated in a number of interlaboratory comparison exercises with exposures in a number of radon chambers. In an EPA Region 8 test of alpha track detectors conducted at EPA's Las Vegas facility, the Barringer ATD gave a concentration 18.0 pCi/l over a 3-day period during which the actual concentration was 18.5 pCi/l (error of 2.7 percent). In other tests conducted at the Department of Energy - Environmental Measurement Laboratory (DOE-EML) the accuracy was typically ±2 - 5% and precision was similar. Numerous tests have been conducted at the DOE-UNC Technical Measurement Center radon chamber in Grand Junction, Colorado. Accuracy has generally been within 10 per cent and precision was consistently ±10 percent or better. Barringer currently has an ongoing tests program with UNC for exposure of nine sets of detectors over the next 12 months.

Barringer has successfully completed participation in Round 5 of the EMP RMP program, as shown in the EPA notification letter (Figure 2-2).

Barringer's quality assurance program is outlined in the document entitled, "Quality Assurance Plan-Radon Measurement Program, Alpha Track Detection", prepared in September, 1988. The QA Plan has been submitted to, and approved by, the U.S. EPA. A

copy is included in this proposal in Appendix A. The plan describes elements of the Barringer program including system calibration, detector custody, and quality control samples, Figure 2-3, presents the table of contents of Barringer's QA Plan.

Standard Operating Procedures

Standard operating procedures (SOPs) developed by Barringer control all activities in the preparation and analysis of ATMs and ensure production of high quality data. SOPs are described in Appendix A of this proposal.

The following discussion briefly describes standard operating procedures for internal quality control which are part of the operating practice of Barringer Laboratories, Inc.

1. Receipt, storage and control of monitoring devices. Incoming shipments are received at Barringer's loading dock, and all shipments or detectors are logged into the facility log book.

2. Chain of Custody

The shipping clerk puts the received shipment under lock and key and informs the intended recipient - the radon division - of the arrival. The shipment is then transferred to the sample preparation and radon division facility and the shipment is entered in the log as having been transferred.

The messenger/drive, upon transferring the shipment to the radon division, enters the shipment into the in-log, and the shipment is checked for completeness.

After the shipment is unpacked, it is transferred to the Laboratory processing lab, and are placed in storage in a nitrogen-purged storage container.

At the end of the laboratory processing and evaluation, the detectors are stored in the laboratory archives, and the accompanying records and shipping papers are filed in the record file.

The chain of custody ends with three events;

a. Reporting of the results to client, with reference as to date and point of origin of monitors to be analyzed.

b. Storage and logging in at lab archives of the physical detectors as they were processed and evaluated, and may be retrieved for rereading at any time.

c. Storage and logging in at lab file storage, of all recording and shipping papers received with the shipment, and with the calculated results.

Every twelve months, or at the end of a major project, sample/ detector and data files are placed in permanent storage for future reference. If a project is continuing, as is the case in many contracts, then the storage is kept active until the project is completed.

3. Document control storage and retrieval.

A single individual is responsible for plant control, safety and standards. This person controls and safeguards the log books and control instruments, ensures that the quality control guidelines have been followed, and ensures that the chain of custody and custody records are in agreement with the transfers and destination of the items covered by them.

4. Equipment calibration and preventive maintenance.

The field of view of the microscopes is checked on a routine schedule and preventative maintenance is performed on a fixed schedule to minimize downtime.

The temperatures of the ovens used during etching the chips are verified with high precision mercury thermometers on all runs. The sodium hydroxide solutions are accurately prepared in our analytical laboratory by trained staff. The solutions are used only once and then discarded. The concentration of the alkali in the solutions are checked with a hydrometer before use.

Office and computing equipment is under service contract, and is serviced and maintained periodically.

5. <u>Traceability of calibration standards and preparation of spikes and duplicates.</u>

Calibration standards, spikes, and duplicates for our program consist of ATDs exposed in calibrated radon chambers operated by the Department of Energy's (DOE) UNC Technical Measurement Center (TMC) in Grand Junction, Colorado or the EPA. ATDs are exposed routinely and there is currently an on-going program with UNC/TMC to regularly expose Barringer ATDs

6. <u>Implementation of contingency plans to isolate and resolve problem areas regarding control data which fail.</u>

In every project there exists the possibility of minor problems if SOPs are not addressed rigorously. However, our QA program and quality control procedures are designed to maintain quality control. The accuracy/precision requirements of the EPA are routinely met in our programs. Should quality control samples indicate a need, corrective action is initiated immediately. This may include exposures of ATDs in the UNC/TMC chamber.

7. <u>Data reduction transcription, verification, and storage.</u>

Data reduction, transcription and verification activities are performed in accordance with SOPs. Data are maintained on hard copy and magnetic media.

8. Validation of methodology which will be employed during the sample analysis.

The high standards that are maintained by the various commercial laboratories that are supplying alpha track detectors in the United States provide a self-policing quality control to the industry. In addition to the continuous calibration at test chambers, the detectors are cross-correlated with radon charcoal canisters and with continuous monitors. Continued participation in the EPS RMP program provides an additional element of quality assurance.

9. Laboratory safety.

Barringer Laboratories are periodically inspected by our own plant safety representatives. We have had no time-loss accidents in the radon division since 1986. Normal laboratory safety practices are followed and appropriate training is provided to all staff.

10. Determination of Lower Limit of Detection (LLD).

The absolute detection limit of the detectors is equivalent to twice the standard deviation of the background counts on an unexposed chip. For this reason, each batch of plastic is carefully checked to determine the individual background levels. Batches with elevated background counts are rejected as unacceptable.

The background levels of the CR-39 plastic that is used in the Barringer ATD yield a detection limit of 4.6 pCi/l/month. Thus, the absolute lower limit of detection is 2.3 pCi/l for a two month exposure, 0.8 pCi/l after six months and 0.4 pCi/l after being exposed for one year.

SCREENING MEASUREMENT
EXPLANATION OF RESULTS

The attached report presents the results of the analysis of your alpha track detector for radon exposure. These results reflect the average concentration of radon only during the exposure period. Radon concentrations are known to very daily and they are dependent upon indoor/outdoor air exchange, therefore the true average radon levels in your home may be somewhat lower or higher than the above reported level.

If the instructions that were provided with your canister were followed, the results would reflect a higher-than-normal level of radon in your home. If the canister was placed in a basement, then the chances are good that the average radon level in the upper portion of your home are somewhat below that reported.

Please be aware that this measurement is only a short term screening measurement designed to indicate if you have a potential radon problem, which may need to be resolved in the near future.

Less than 4 pCi/l - Follow-up measurements are probably not required. If your house was closed up prior to and during the exposure period, than chances are the average annual radon concentration in your home will be somewhat less than the reported result. Exposures in this range are considered average or slightly above average for residential structures. Reductions of levels this low may be difficult to achieve.

4 pCi/l to 20 pCi/l - You should perform follow-up measurements by exposing long term alpha track detectors for a period of six months to one year. Exposures in this range are considered above average for residential structures. You should undertake action to lower levels to about 4 pCi/l or below. The EPA recommends that you take action within a few years, sooner if levels are at the upper end of this range.

20 pCi/l to 200 pCi/l - You should perform follow-up measurements by exposing alpha track detectors for one to six months depending upon the level. If the screening measurement was in the upper end of this range you should verify that level with a second charcoal canister measurement. Exposures in this range are considered greatly elevated and you should take immediate steps to reduce levels as far below 20 pCi/l as possible. The EPA recommends you take action within several months.

ATD Report Form

BARRINGER LABORATORIES INC.

[illegible] W. [illegible] AVE. SUITE [illegible]
GOLDEN, COLORADO [illegible]
PHONE: [illegible]

[illegible] WARD ROAD
WHEAT RIDGE, COLORADO [illegible]
PHONE: [illegible]

RADON MEASUREMENT DATA SHEET

SEND RESULTS TO:

NAME: Dave Smith

DETECTOR #: 1234
(# on white label)

ADDRESS: 1234 Poverty Lane

CITY & STATE: Anywhere, USA ZIP CODE: 00000

PHONE #:

CLIENT-FILL IN THIS SECTION ONLY

Name: Dave Smith

Date/Time Detector Placed: 1/1/88; 9:00 [illegible]

Address: 1234 Poverty Lane
Anywhere, USA 00000

Date/Time Detector Resealed: 1/1/89; 12:30

Phone:

Describe house construction, where detector was placed and weather conditions during exposure period: Basement

---

LABORATORY USE ONLY

Date Received: 2-1-89

Received By: CMC

I.wt.

F.wt.

Date/Time Ct.: 2-2-89

	ROLA	ROIB	ROIC
t.cts.			
b.cts.			

RESULTS OF ANALYSIS

Radon Concentration: 4.4 ± 1.5 pCi/L±*

* Variability of the radioactive disintegration process(counting error) at th 95% confidence level, 2σ

Approved By: DL

BARRINGER LABORATORIES INC.

[illegible] W 6TH AVE SUITE 200
GOLDEN, COLORADO 80401
PHONE (303) [illegible]

[illegible] WARD ROAD
WHEAT RIDGE, COLORADO 80033
PHONE (303) [illegible]

TO.

Date Received: ____________

Received by: ____________

Approved by: ____________

Client—Fill in This Section					Laboratory Use Only				
SERIAL #	CLIENT ID	DATE/TIME PLACED	DATE/TIME RESEALED	DATE/TIME COUNTED	TOTAL COUNTS BKG	1	2	NET	RADON pCi/L =

NATIONAL RADON MEASUREMENT PROFICIENCY (RMP) PROGRAM

CUMULATIVE PROFICIENCY REPORT

EPA Test Round 5

Research Triangle Institute
Radon Technical Information Service
Research Triangle Park, NC 27709

Prepared for the

Radon Division (ANR-464)
Office of Radiation Programs
U.S. Environmental Protection Agency
Washington, DC 20460

Under the Direction of
U.S. EPA Task Manager
Joseph R. Gearo, Jr.
National Coordinator
National RMP Program

September 1988

EXPLANATION OF ABBREVIATIONS

Methods	Units
AT - Alpha Track Detection	(pCi/l)
CC - Activated Charcoal Adsorption	(pCi/l)
CR - Continuous Radon Monitoring	(pCi/l)
CW - Continuous Working-Level Monitoring	(WL)
GR - Grab Radon Sampling	(pCi/l)
GW - Grab Working-Level Sampling	(WL)
RP - Radon Progeny Integrated Sampling Unit/RPISU	(WL)
EP - Electret-PERM	(pCi/l)

Measurement Units

pCi/l - Pedicuries per liter air, radon gas measurement units.

WL - Working-level, radon decay products measurement units.

Definition of Performance Indicator

Li - Signifies a company's ability to meet all program requirements with the given measurement method in the performance test.

Qi - Same as Li, except the company has an approved QA plan on file with EPA.

HL - Signifies a method's omission from the CPR because of unsuccessful participation. This indicator is only used when a method has passed a round, then failed, resulting in its performance record being omitted from a previous report, and has now passed again. "NL" is used in the method's reinstated performance records.

Others

QA Quality Assurance.

QT - Detector(s) damaged or lost through no fault of the participant.

TABLE 2
PERFORMANCE RESULTS OF COMPANIES

* Company	Date of Round	Radon Measurement AT	AT	CC	CC	CR	CR	EP	EP	GR	GR	Working Level Measurement CW	CW	RP	RP	GW	GW
Audubon Controls, Inc. P. O. Box 477 Audubon, PA 19403 Silas A. Belden (215) 666-7889	9/88					L1											
BBC & M Engineering 205 Chittenden Ave. Columbus, OH 43201 Richard Brown (614) 294-3745	9/88				L1												
BCA Laboratory Inc. P. O. Box 3722 Bloomington, IL 61702 Don Curry (309) 828-4259	9/88											L1					
BCT 12 Magnolia Ave. Denville, NJ 07834 Kevin Scollans (201) 627-2882	11/86 5/87 9/88				Q1 Q1 Q1												
Baltimore Gas & Electric Company Rutherford Business Center P.O. Box 1475 Baltimore, MD 21203 Dr. Lawrence John Bartel (301) 281-3781	9/88			Q1													
Bar-Tel Infrascan 746 Kirkland Circle F-102 Kirkland, WA 98033 Fred C. Bartel (206) 822-1402	9/88				L1												
Berringer Laboratories, Inc. 15000 West Sixth Avenue, Suite 300 Golden, CO 80401 Bruno E. Sabels (303) 277-1687	7/85 11/86 5/87 9/88	 Q1		Q1 Q1 Q1 Q1													

* See TABLE 1 for the States each company serves.
Note: Underscored performance indicators denote a primary company capable of performing measurement analyses in-house or making measurements using operators and instruments belonging to the company. See Definitions of Performance Indicators on page 7.

EXHIBIT C

PERSONNEL

STAFF MEMBER	BACKGROUND AND EXPERTISE OF PERSONNEL
Dr. John S. Lovell	Laboratory Director. Over 12 years experience in soil-gas geochemistry, including radon.
David B. Lasher, Radiochemistry/Radon Manager	B.S. Degree, Chemistry/Biology. Nine years experience in analytical environmental chemistry inorganic and radiochemistry. Three years experience in radon measuring systems.
Edward C. Loshbaugh, Senior Chemist	Thirty-two years analytical chemistry experience for uranium mining, milling, exploration and environmental controls. Twenty-five years experience in radon and radiation safety. Established and operated radon measuring systems for two uranium mills.
Larry Eggleston, Laboratory Technician	Eleven years water/wastewater laboratory experience. Class B wastewater treatment plant operators license. One year experience in radon laboratory.
Irma Pottruff, Laboratory Technician	Five years laboratory experience as quality control technician. One year experience in the radon laboratory.
Chris Cunningham, Laboratory Technician	B.A. Degree, Molecular Biology. Two years laboratory experience. One year experience in the radon laboratory.
Jeremy Burton, Laboratory Technician	B.S. Degree, Marketing. One year experience in radon laboratory.

ATTACHMENT 6

Barringer Laboratories Inc.
Radon Measurement Program and
QA/QC Procedures for
Activated Charcoal Canister

QUALITY ASSURANCE PLAN

RADON MEASUREMENT PROGRAM

ACTIVATED CHARCOAL

4" OPEN FACE CANISTER

BARRINGER LABORATORIES INC.

15000 WEST 6TH AVENUE, SUITE 300

GOLDEN, COLORADO 80401

Prepared by: David B. Lasher
March, 1989

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XI. INTRODUCTION

Increased public awareness of the radiation hazards associated with the uranium and nuclear industries has demanded a continuous program of monitoring the environment. The accurate and reproducible measurement of radioactivity in environmental materials is of utmost importance to any surveillance program related to these industries.

Barringer Laboratories' Radiochemistry Quality Assurance Program was developed to insure that our laboratory produces the highest quality data for its industrial and governmental sponsors. The program is intended to be continually updated and changed to meet new regulatory requirements, and to take advantage of new technology.

Our Quality Assurance Program is based on the recommendations of the U.S. Nuclear Regulatory Commission, Office of Standards Development, Regulatory Guide 4.15 entitled "Quality Assurance for Radiochemical Monitoring Programs (Normal Operations) - Effluent Streams and the Environment (1977) and the EPA Manual for the Certification of Laboratories Analyzing Drinking Water (Criteria and Procedures Quality Assurance), EPA-570/9-82-002 (October 1982).

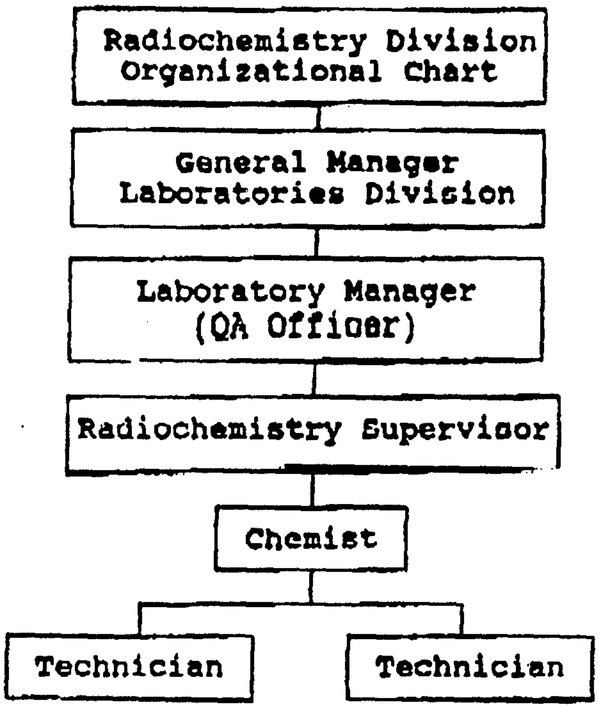
We have maintained our certification for all radiochemical parameters under the Safe Drinking Water Act since 1979.

The primary purpose of this quality assurance manual is to establish guidelines for the Radiochemical Laboratory to assure that analytical data being reported by this laboratory (1) are valid and are of known and acceptable precision and accuracy, (2) are representative, and (3) have the necessary documentation available in support of the analytical results.

2.0 Organization and Responsibilities

Radon/radon progeny measurement services are provided through the Radiochemistry Division.

2.1 Organization



2.2 Responsibilities

Laboratory Manager - Responsible for the overall operation of the entire laboratory, including review of the QA/QC program for compliance by each division.

Radiochemistry Supervisor - Responsible for the operation of the Radiochemistry Laboratory. Responsibilities include; training of personnel, procedure development, data assessment, implementation of QA/QC procedures and maintenance protocols, workflow, identifying problem areas and implementing corrective action.

Chemist - To perform any and all analyses offered by the laboratory with proficiency. To assist the laboratory supervisor and provide technical assistance to the technicians. To report any procedural or analytical problems encountered in the laboratory to the supervisor.

2.2 Responsibilities (cont'd)

Technician - To perform routine analyses with little or no supervision as specified by the supervisor. Must complete a training program and show proficiency with an assigned procedure before performing on a routine basis. Responsibility includes reporting any problems encountered in the laboratory to the immediate supervisor.

3.0 Radon Measurements

3.1 Overview - Charcoal Canister Method

The concentration of radon in air is determined by adsorption on activated charcoal contained in a sealable cylindrical canister and subsequent gamma counting of the Radon-decay daughters, Pb-214 and Bi-214, using a 3" x3" NaI detector and multichannel analyzer. After corrections for humidity, exposure period, and elapsed time between sampling and counting, the concentration of radon in air is determined using a calibration curve derived according to procedures as outlined by A. George (Health Physics, Vol. 46, 1986) and B. Cohen (Health Physics, Vol. 45, 1983). The detection limit for this procedure is 0.1 pCi/l for an exposure period of from three to four days. (See lower limit of detection under section 3.3).

3.2 Equipment

Radon Detector - Charcoal canister (4" x 1¼) containing approximately 80 grams of activated charcoal. Manufactured by F and J Products, Miami, Florida. Model No. RA40V, 8 x 16 mesh charcoal. Meets EPA specifications.

Instrumentation - Four 3" x 3" NaI gamma detectors (Canberra Model 802-4) coupled to an Ino-Tech 5200 multichannel analyzer for measurement of PB-214 and Bi-214 decay.

3.3 System Calibration

Charcoal canisters are calibrated by exposure of a representative portion of the canisters to a known radon concentration under controlled humidity for specified time intervals of anywhere from one to seven days.

For calibration purposes, forty-five of our canisters were sent to the federal radon exposure facility in Montgomery, Alabama for exposure to know concentrations of radon. Three sets of 15 canisters were exposed at 100 pCi/l radon concentration under 25%, 50% and 80% humidity, for one, two, three, four and five day intervals, respectively. The exposed canisters were counted for thirty minutes on a calibrated NaI gamma detector and MCA. The energy regions on the MCA were positioned to count the gamma emissions of Pb-214 and Bi-24 from 0.25 to 0.61 Mev.

The data obtained from these exposures were used to derive calibration curves according to procedures as outlined by A. George (Health Physics, Vol. 46, 1986) and B. Cohen (Health Physics, Vol. 45, 1983).

The lower limit of detection (LLD) for this method is determined by the below function, which is taken directly from the Nuclear Regulatory Commission (NRC) version:

$$\text{LLD (pCi/l)} = \frac{4.66\sqrt{\frac{B}{T'}}}{2.22(E)(CF)(M)(P)} \quad \frac{1}{e^{-\lambda t}}$$

Where
B = total background counts
T = count time in minutes
E = overall efficiency - includes instrument and canister efficiencies
CF = calibration factor, liters/minute
P = exposure period, minutes
M = % moisture gain
λ = radon decay constant

Our typical background count rate is 298 cpm over 33.3 minutes, with an overall efficiency (E) of 0.20. For a three day exposure period at 50% humidity, the derived calibration factor (CF) is 0.081 liters/min. Assuming minimal elapsed time between sampling and counting, the lower limit of detection for the three (3) day exposure period at 50% humidity is 0.1 pCi/liter.

3.4 Charcoal Canister Preparation

New and previously exposed canisters re prepared in the same manner. With the canister lids removed, the bottom halves containing the activated charcoal are placed in an over at 120 degrees centigrade for 6-8 hours to drive off any moisture and radon adsorbed during a previous exposure period or during shipment. Afterward, the canisters are removed from the oven and covered with their lids while still warm to prevent any ambient moisture and background radon from being adsorbed prior to weighing and resealing. Once cool the canisters are weighed to the nearest 0.01 grams, resealed with tape, and stored until ready for exposure. The holding time for canisters in storage is 45 days.

For shipping purposes, charcoal canisters are mailed in protective cardboard cartons along with an instruction sheet and homeowner date-entry form.

3.5 Detector Custody

All canisters are assigned unique serial numbers, and a history is maintained on detector control sheets where the date shipped and the name of the person or organization to whom shipped is entered. These control sheets are kept on file and remain in the laboratory until the detector is returned for analysis.

Accompanying each detector shipment is an instruction sheet and a homeowner data entry form (see Appendix). The homeowner or person exposing the detector enters his or her name and all pertinent information including dates and times of exposure, and returns this form along with the exposed detectors to the laboratory. Upon receipt at the laboratory, the forms are signed and dated by the receiver and the appropriate detector control sheets are pulled from their respective file. The date returned is then noted on both the homeowner data-entry form and the detector control sheet.

3.6 Placement and Exposure

In brief, canisters which have been previously prepared, are opened and exposed from three to four days in an area of the home or building where the radon concentration is to be determined. The homeowner is instructed to place each canister in the middle of the room approximately two feet above the floor on a box or chair away from any windows, heating systems, or fans. All windows and doors are to be closed at least 12 hours prior to and during the exposure period, and any indoor/outdoor air exchange

systems are to be off during this time. If severe weather or high winds are predicted, placement is to be postponed until milder weather.

At the end of the exposure period, canisters are to be resealed and returned to the laboratory for analysis along with the homeowner data-entry form as soon as possible, and in any case less than seven days. Any pertinent information including dates and times of exposure, canister placement, house description, and weather conditions are recorded onto this form.

More detailed information concerning canister placement is found in the "Radon Measurement Instruction Sheet) (see Appendix).

3.7 Instrument Calibration

Prior to each day of counting, the NaI gamma detectors and MCA are set-up according to the Ino-Tech operating manual. Initially, an NBS traceable 10 nanocurie BA-133 (0.35 MeV) standard is used to check each detector calibration. The total count rate must be less than three (3) standard deviations from the average Ba-133 count rate for each detector before counting can begin.

As a second calibration check and to facilitate identification of the Pb-214 and Bi-214 gamma peaks between the energy range 0.25 to 0.61 MeV, a canister spiked with 100 pCi of Ra-226 standard (NBS traceable) which was allowed to equilibrate with its radon daughters is counted for 2000 seconds. The PB-214 and Bi-214 peaks produced are easily identified on the MCA and the energy regions can be set accordingly. For counting to continue, the results from this calibration step must be less than three (3) standard deviations from the average of previous calibrations.

To check for the instrument background count rate, an unexposed blank canister is also counted for 2000 seconds. The total counts must be less than three (3) standard deviations from the average background rate. These results along with the above instrument calibration checks are entered into the instrument log-book, and compared against control charts for compliance with standard deviations. These control charts aide in identifying trends and out of control data. In addition, instrument resolutions re-checked monthly by counting a mixed NBS standard of Ba-133 and Cs-137.

Before counting of exposed canisters can begin, all of the above criteria must be satisfied.

3.8 Canister Analysis

After receipt at the laboratory, exposed canisters are logged-in with the date of receipt noted on both the homeowner data-entry form and the canister control sheet by the person doing the receiving.

Canisters are counted for PB-214 and Bi-214 decay activity as soon as possible, preferably within 24 hours and no more than 48 hours after their arrival. Each canister is counted for 2000 seconds (1000 seconds can be used if necessary). The date and time of counting are noted on the homeowner day-entry form along with the total counts for the the analysis.

After counting, the canisters are submitted for determination of their final weights which are recorded onto the data-entry forms.

3.9 Data Reduction, Validation, and Reporting

To determine the radon concentration, the background count rate (B) is subtracted from the gross Pb-214/Bi-214 count rate (G) to arrive at the net count rate (N). Assuming equilibrium conditions, meaning the rate of decay of radon is equal to the rate of decay of Pb-214/Bi-214, the net count rate is corrected for the decay of radon from the time of exposure to and including the time of analysis. After corrections for instrument counting efficiency (E), the total activity of radon in pCi is determined. Depending upon the period of exposure (P) and % moisture gain (M) during canister placement, the concentration of radon in pCi/liter of air is determined by use of the previously determined calibration factor (CF). The results are calculated as follows:

$$\text{Radon pCi/liter} = \frac{(G-B)}{2.22(E)(CF)(M)(P)} \quad \frac{1}{e^{-\lambda t}}$$

where,
- G = Pb-214/Bi-214 gross count rate, cpm
- B = Background count rate, cpm
- E = Instrument counting efficiency, cpm/dpm
- CF = Calibration factor, liters/minute
- M = % Moisture gain
- P = Exposure period, minutes
- λ = Radon decay constant
- t = Elapsed time (minutes), between exposure and end of count
- N = Net count rate = (G − B), cpm
- T = Count time, minutes

3.9 Data Reduction (cont'd)

The final results are reported in pCi/liter with a plus or minus 955 counting error of 2 sigma, which is determined by the following calculation

$$\text{Counting error} = \frac{1.96\left(\frac{C}{T} + \frac{B}{T}\right)^{\frac{1}{2}}}{2.22(E)(CD)(M)(P)} \quad \frac{1}{e^{-\lambda t}}$$

The calibration factors used to determine the total radon concentration are part of a computer program stored in memory on an HP-97 calculator. Each result is preceded by a printout of the background count rate, standard deviations, % moisture gain, exposure period, elapsed time between exposure and counting, calibration factor (Liter/minute), and the result. An error during data entry or unacceptable standard deviations can easily be recognized on the computer printout if one is familiar with the calculations.

The results are reported on the homeowner data-entry form which is submitted along with the computer printout to the laboratory supervisor for approval. The laboratory supervisor will check the calculations for any data entry errors and compliance with standard deviations. Any results that look out of line re rechecked for mathematical errors or any discrepancies in weights, times, or counts. If necessary, a canister is resubmitted for analysis.

A copy of the final report is kept on file at the laboratory for future reference and the original is returned to the homeowner along with an information sheet (see Appendix) explaining the results and what action, if any, should be taken.

4.0 Quality Control

The charcoal canister system is considered to be an acceptable and inexpensive method for measuring indoor levels of radon. If the system has been properly calibrated and appropriate quality control checks are performed on a regular basis, this method can provide a good degree of accuracy and precision for radon measurements. Although it is a short term method, it is useful as a screening procedure for potential indoor radon problems.

The objective of the following quality control parameters is to establish and maintain procedures that help assure the integrity and reliability of the analytical results.

4.0 Quality Control (cont'd)

Since both a product and a service are being provided, the canisters as well as the internal laboratory procedures are monitored for both quality and performance. Canisters are monitored for changes in calibration efficiencies, background counts, and weights and laboratory procedures are monitored for problems during canister preparation, storage, and analysis.

4.1 Canister Control Sheets

To provide an historical record for each canister and to monitor the canisters for discrepancies in initial weights and above average backgrounds, each canister has its own control sheet which is kept on file at the laboratory. Weights, background levels, dates shipped and returned, and to whom shipped are entered onto these forms.

4.2 Monitoring Canister Weights

Gains or losses in canister weight, due to adsorption of moisture or loss of charcoal, can have a significant effect on the final results of an analysis. The purpose of monitoring canister weights is two-fold, (1) drying ovens can be monitored for their efficiencies at driving off adsorbed moisture (directly), and radon (indirectly), and (2) any loss of charcoal or unusual gain in weight which would affect a canister's efficiency can be identified.

Since moisture gain can affect the ability of the canisters to adsorb radon and thus their efficiency, it is important that any moisture adsorbed onto the charcoal during a previous exposure be eliminated prior to re-exposure. Usually heating the canisters at 120 degrees centigrade for 6-8 hours is sufficient to drive off any remaining ambient moisture, however, on occasion some canisters may require longer periods in the oven.

To assure sufficient loss of moisture during canister preparation, the initial weight of each canister after removal from the drying oven must not be greater than 0.5% (approximately 0.8 grams) of the previous weight as shown on the canister control sheet. Any canisters which are greater than this limit must be returned to the oven for another 6-8 hour period to guarantee moisture loss. The initial dry weight is recorded onto the canister control sheet as the final dry weight if it falls within the above limit. If not, the secondary weight, instead, is recorded onto the control sheet as the final dry weight.

4.2 Monitoring Canister Weights (cont'd)

Once assured moisture from a previous exposure has been eliminated, it is necessary to monitor the canisters for changes in weight due to losses of charcoal. Assuming that small percentage losses in charcoal show a proportionate decrease in canister efficiency, an arbitrary limit of 2% has been placed on the final dry weights. Meaning, a canister must be within 2% of the average of its previously recorded dry weights in order to remain in the measurement program. Any canisters over this limit are pulled from circulation and discarded.

4.3 Monitoring Canister Backgrounds

Canisters are monitored for background levels during their preparation, storage, and shipment. Prior to removal of each batch of canisters from the oven, a canister, preferably with a previous exposure that was high in radon, is chosen for a background determination. Background counts are taken for 2000 seconds each and the results must be less than three (3) standard deviations of the average background count rate as previously determined on a blank, unexposed canister before a batch is considered ready for removal from the oven, final weighing and subsequent storage.

Before each batch of canisters is shipped out for exposure, one canister is chosen for a background determination. The result must be less than plus or minus three (3) standard deviations from the average background rate before the canisters are allowed to be shipped. If it is not, the entire batch is monitored for background to determine the extent of the problem. Those canisters which are over the limit are returned to the oven for further preparation.

4.4 Calibration Verifications and Maintenance

To verify the accuracy of the calibration curve for the charcoal canister system and to evaluate the overall laboratory performance, canisters are sent on a regular monthly basis (subject to chamber availability) to the EPA radon facility in Montgomery, Alabama for exposure to known concentrations of radon. In addition, Barringer Laboratories are enrolled and has participated successfully in the test rounds of the EPA Radon/Radon Progeny Measurement Performance Evaluation (RMP) Program. As part of our QC program, we intend to continue enrollment in the RMP Program and plan to participate in all of the upcoming rounds.

4.4 Calibration (cont'd)

The results of analyses for the calibration verifications and the EPA "blind" exposures are maintained in the QC logbook, along with precision and accuracy data.

To maintain accuracy and precision of the system it is important that canister geometry, charcoal amount, mesh size and typed be consistent. We chose this particular canister system and manufacturer because of their use by the EPA in their radon measurements program. These canisters meet U.S. EPA specifications as to mesh size and charcoal type. The manufacturer has been instructed to notify our facility of any changes in these specification.

New canisters are monitored for discrepancies in charcoal amount when final dry weights are determined. The canister weights must fall within the range of 154-162 grams (a range of approximately 5%) to remain in the program.

4.5 Duplicates and Blanks

To evaluate precision and monitor background levels, duplicate analyses and blanks are preformed on a 10% basis. Results of these exposures are maintained in the QC logbook.

4.6 Instrument Logbook

Instrument calibration and background level check for each day of counting are maintained in the instrument logbook, along with a client list of canisters counted for that day.

5.0 Precision and Accuracy Assessment

The following precision and accuracy statement address our charcoal canister system and its observed performance (system is defined as both the canisters and the counting equipment combined, and no attempt will be made to separate the two).

To check the accuracy of our calibration curves at different levels of radon concentration and humidity, several groups of canisters were sent to the EPA radon facility in Montgomery, Alabama, for exposure at known concentrations of radon, and humidity. The results are tabulated on the next page.

Exposure (Hours)	Percent Humidity	Result pCi/l 1	2	3	Avg.	Std. Dev.	Known	Dev. Known
24	50	28.1	27.8	28.1	28.0	0.17	24.8	0.13
48	50	29.7	29.2	29.1	29.3	0.32	25.2	0.16
72	50	38.4	28.1	27.3	27.9	0.57	25.0	0.12
96	50	27.2	26.4	27.5	27.0	0.57	24.9	0.08
122	50	26.2	27.0	26.2	26.5	0.46	25.6	0.04
24	80	105	105	107	106	1.15	95.8	0.11
72	80	106	104	105	105	1.00	102	0.03
96	80	92.4	91.3	90.8	91.5	0.82	98.1	0.07
30	25	16.2	16.9	16.0	16.4	0.47	16.9	0.03
96	25	15.1	15.2	14.8	15.0	0.21	16.3	0.08

6.0 Performance and System Audits

It is the responsibility of the QA Officer to perform audits on a regular basis of the laboratory and quality control procedures, to assure these procedures are being followed and the necessary documentation maintained and kept up to date. These audits shall be performed on a quarterly basis, and the results shall be maintained in the QA Officers audit notebook.

The audit shall include (1) a check of the counting equipment and the instrument logbook for property calibration procedures and maintenance protocols, (2) a check of the canister control sheets for property maintenance of canister weights and backgrounds, and (3) a check of the quality control logbook for frequency and results of calibration verifications, "blind" EPA analyses, duplicates and blanks.

7.0 Corrective Action

The laboratory supervisor is to be notified immediately of any problems or discrepancies encountered during any part of the radon measurement process. It is is his or her responsibility to initiate corrective action to resolve those problems as soon as possible.

The procedures as outlined in this manual are designed to minimize the chances for error, and to identify problems or potential problems before they have had the opportunity to do significant harm to the quality of data. Some corrective measures have already been addressed in the previous sections of this manual. More serious problems dealing with instrument or system calibrations may have to be addressed separately, referring to instrument manuals or other outside references.

8.0 QA Report to Management

The results of the quarterly performance and system audits by the QA Officer are to be submitted to both the laboratory supervisor and upper level management for their evaluation. In addition, management is to be notified of any problems encountered or brought to the attention of the laboratory supervisor which may require an upper level management decision.

9.0 Appendix (attached)

Measurement Instruction Sheet
Data Sheet - Results of Analysis
Explanation of Results

SCREENING MEASUREMENT
CHARCOAL CANISTER
INSTRUCTION SHEET

Enclosed is a charcoal canister device for measuring indoor radon levels. This is a short term screening measurement designed to indicate if you have a potential radon problem which would require further attention.

Instruction for use:
Check weather conditions before placement of the canister. If severe weather, particularly high winds, is predicted during the exposure period (which is usually 2 to 3 days) wait until milder weather is forecast.

Keep windows and doors closed and turn off all internal-external air exchange systems (other than a furnace) such as attic and window fans within the area of canister placement at least 12 hours prior to and during the measurement period. Try to keep the opening and closing of doors and windows down to a minimum. Air conditioning systems which recirculate interior air may be operated if necessary.

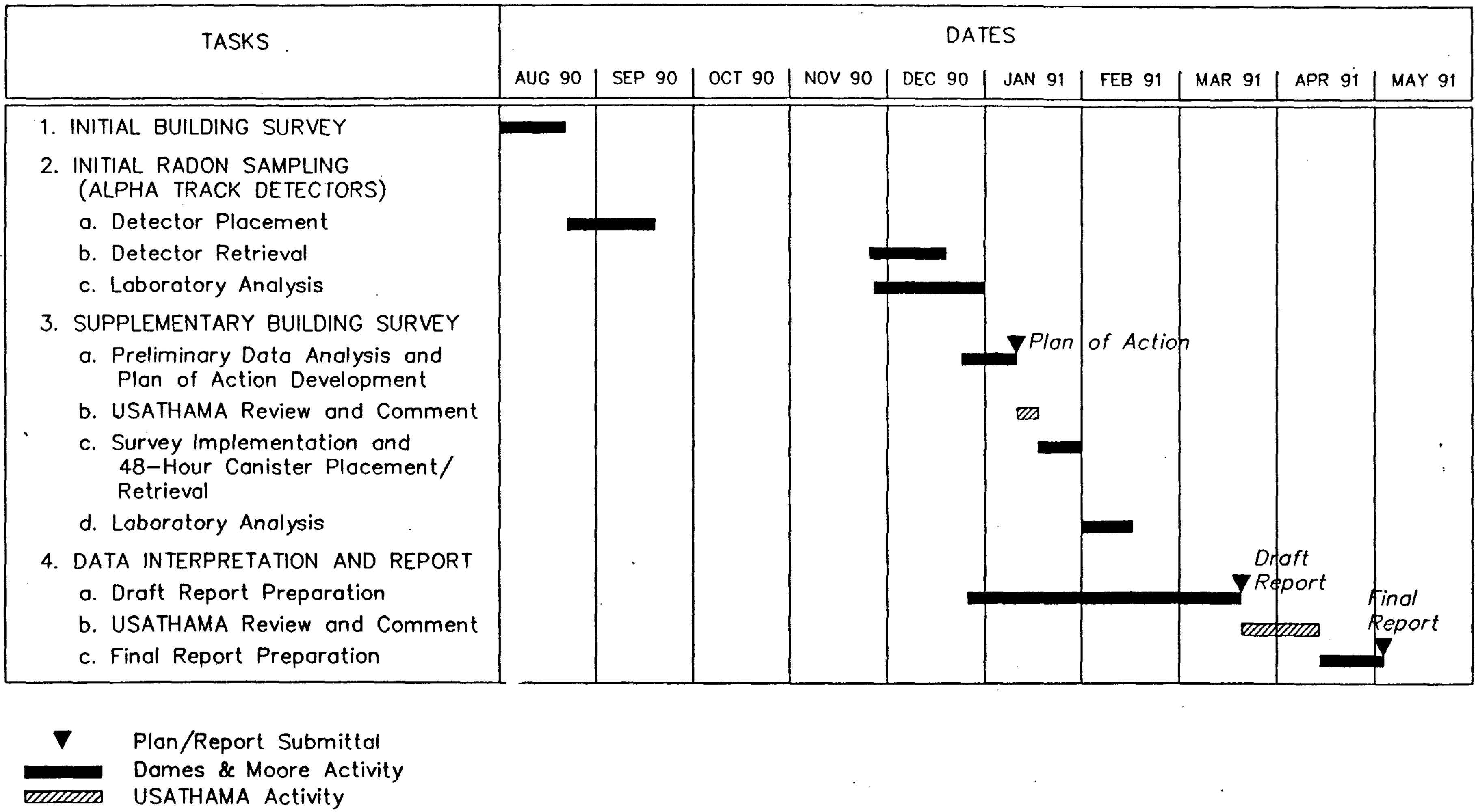
Place the canister in an area where the radon concentration is likely to be the highest. Basements are usually the first choice, followed by ground level rooms. If radon levels in these areas are determined to present significant health risks, then a second canister placement in upstair rooms may be considered.

Preferably place the canister in the middle of the room, approximately two feet above the floor on a box or chair, away from any windows, exterior walls and/or heating and cooling equipment.

To expose the canister, peel off the tape which seals the top and bottom halves of the canister together. (Save this tape because you will reuse it to reseal the canister after the exposure period.) Lift off the lid exposing the charcoal in the bottom half of the canister which acts as the radon absorber. Place this canister with the screen side up in the area you have previously selected. Record the date and time and any other pertinent information on the accompanying form.

Let the open canister stand undisturbed for a period of two to three days. At the end of this period, replace the lid and reseal the two halves together with tape. Record the date and time the canister is resealed on the accompanying form.

Return the canister with the completed data sheet as soon as possible to BARRINGER LABORATORIES INC., 1500 W. 6TH AVE., # 300, GOLDEN, COLORADO 80401. It is important that we receive the canister no later than seven days after the measurement period. You will receive a written report of analysis within 5-7 days after receipt at the laboratory. If you have any questions or need further information, please call our toll free number 1-800-654-0506 (within Colorado call 277-1687).



ATTACHMENT 7
SCHEDULE FOR
RADON SCREENING OF BUILDINGS AT UMDA

DAMES & MOORE